ADAPTABILITY PERFORMANCES OF SOME SOFT WHEAT
(*TRITICUM AESTIVUM* VAR. *AEST.* L.) CULTIVARS IN THE
MARMARA REGION OF TURKEY

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Abstract

This study was conducted to determine the adaptability and stability of 7 wheat cultivars, viz., Cumhuriyet-75, Momtchill, Tosun-22, Gemini, Katea-1, Kirkpinar-79 and Atilla-12 under Bursa conditions for nine years between 1986 and 1996. The trials were conducted at the Research and Application Center of Faculty of Agriculture located at Görükle Campus of Uludağ University.

Cultivars were sown in October in 10 x 12-m plots, which were arranged as a randomized complete block design with four replications. In the study in which grain yield was used a criterion to determine stabilities of soft wheat cultivar, three stability parameters: regression coefficient (b), mean squares of deviation from regression ($S^2$) and determination coefficient ($r^2$) values were calculated. The years were considered as an environment in the study.

According to the results, genotype x environment interactions for grain yield was highly significant. Thus, the stabilities of seven soft wheat genotypes were different for grain yield. According to the stability parameters, Momtchill, Katea-1, Gemini and Kirkpinar-79 were stable, while Atilla-12, Tosun-22 and Cumhuriyet-75 were no stable for grain yield. Genotypes Tosun-22 and Atilla-12 could be considered as having high adaptability to poor condition, but Cumhuriyet-75 adapted to good environments. On the other hand, the genotypes Momtchill, Katea-1 and Kirkpinar-79 whose yields were higher than mean yield of trial (5310 kg ha$^{-1}$) could be considered as having good adaptability to all environments.

Introduction

Wheat is world's leading grain crop and Turkey is one of the most important wheat producer in the world. The Marmara Region located in northwest Turkey is an important wheat production area in Turkey with a cultivation area of 500,000 ha with an average yield of 2640 kg ha$^{-1}$ (Anon., 1996).

Genotype-environment interactions and adaptation studies are widely used in wheat breeding programs to assist in the selection of genotypes for different management and environmental regimes. Sometimes inconsistent results were obtained in genotype-environment interactions among wheat genotypes from one environment to another. This inconsistency may arise in responses of the same genotypes to different environments, or different genotypes in different environments (Falconer, 1952; Robertson, 1959; Cockerham, 1963). When assessing grain yield of wheat cultivars in a multi-environment trial, changes are commonly observed in the relative yield performance of the cultivars.

The widely used procedure for modeling statistical interaction is a simple regression of the cultivar performance on the site mean (Yates & Cochran, 1938; Finlay & Wilkinson, 1963; Eberhart & Russell, 1966; Vargas et al., 1998; Vargas, et al., 1999; Crossa et al., 1999). A widely used technique for characterizing genotype x environment interactions and to predict varieties response was proposed by Eberhart & Russell (1966). This method requires analysis of stability parameters of genotype performances over a series of experiments. Mean yield of individual genotype is regressed against the environmental

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index to provide 2 stability parameters. One is a regression coefficient (bi) for comparing relative response of a particular genotype to average of all genotypes. Another parameter is the deviation from regression mean square (S^2 d) for measuring how well the predicted response arise with the observed response.

The determination of well-adapted cultivars is of importance, because of the ecological suitability of Marmara region and the importance of wheat production in the region. The stability and adaptability of seven soft wheat cultivars was determined for seed yield across a nine-year period in Bursa region. The results will provide the basis for future research and to assist in the selection of cultivars to be used under different management and environmental regimes.

The objective of this study were twofold: (i) to determine cultivar x environment (C<sub>x</sub>Y), identify stable genotype, and (ii) to compare the stability parameters at the Research and Application Centre of Faculty of Agriculture located at Gurukle Campus of Uludag University, Turkey.

**Materials and Methods**

**Plant materials:** Seven soft wheat cultivars viz., Cumhuriyet-75, Mornchill, Tosun-22, Gemini, Katea-1, Kirkpinar -79 and Atilla-12 were used in the study.

**Environment:** The experimental area is located in the coastal zone of northwest Turkey (40°11' North, 29°04' West), 70 m above the sea level.

Average annual rainfall of Bursa province is about 699 mm year<sup>-1</sup>, the distribution of precipitation is uneven and nearly 90% occurs during the period when wheat exists in the field. Evaporation is 1048 mm year<sup>-1</sup>, mean temperature for the whole year is 14.7° C and relative humidity average is 69% (Anon, 1999). During the experimental period, average November–March temperature and precipitation was 6.9° C and 70.0 mm, May-June was 19.3° C and 39.2 mm (Figs. 1,2).

The soil of experimental field is heavy-textured, slightly alkaline (pH is 7.2), contains no salt, classified as vertisol typic halbioxert, low in organic matter (1.4 %) and high in available phosphorus (73 kg ha<sup>-1</sup>) and potassium (1130 kg ha<sup>-1</sup>).

**Experimental design and cultural practices:** Plots consisted of eight row spaced 15 cm apart and 10 m long. Plots were arranged in randomized complete block design with four replications. 8.1 m<sup>2</sup> (Turan, 1988). The recommended fertilizer consisting of nitrogen, in the form of nitrate and phosphorus (20:20:0) were manually drilled and incorporated in the soil both @ 50 kg ha<sup>-1</sup> at planting. Fertilizers that supplied 100 kg ha<sup>-1</sup> NH<sub>4</sub>N<sub>2</sub>O<sub>3</sub> (26%) were uniformly sprayed in early spring. Weeds were controlled by herbicides. Data on seed yield were taken from the middle six rows (8.1 m<sup>2</sup>) of each plot. The plot yield was converted to kg ha<sup>-1</sup>.

**Statistical analyses:** Analyses of variance were computed for the seed yield data within and across the nine years of the study. The variance of "Homogeneity of Regressions" and "Regression-Biased Variance were partitioned from the cultivar x year interaction sum of squares in the analyses of variance (Eberhart & Russell, 1966; Yildirim et al., 1979). The "Simple Regression Method" was used in estimating the adaptation and stability parameters (Finlay & Wilkinson, 1963). The regression coefficient (bi), regression-biased square means (S<sup>-i</sup>, xi) and determination coefficient (r<sup>2</sup>) were estimated.
Fig. 1. Temperature data of 1988-1996 years and long-term average in Bursa.

Fig. 2. Precipitation data to belong to 1988-1996 years and long-term average Bursa.
1. Regression coefficient \((b_i)\) for 1 th genotype proposed by Finlay & Wilkinson (1963) was defined by the following formula:

\[
b_i = \frac{\sum_{j=1}^{m} Y_{ij} X_j - (\frac{1}{m} \sum_{j=1}^{m} Y_{ij}) (\frac{1}{m} \sum_{j=1}^{m} X_j)}{\frac{1}{m} \sum_{j=1}^{m} X_j^2 - (\frac{1}{m} \sum_{j=1}^{m} X_j)^2}
\]

where \(i\) and \(j\) explain genotype \((1-7)\) and environment \((1-9)\), respectively. In addition, \(m\) was number of environments.

2. Mean squares of deviations from regression \((S_{di}^2)\) proposed by Eberhart & Russell (1966) was calculated by the following equation:

\[
S_{di}^2 = \frac{1}{m(m-2) \sum_{j=1}^{m} Y_{ij}^2 - (\frac{1}{m} \sum_{j=1}^{m} Y_{ij})^2} \sum_{j=1}^{m} x_{ij}^2
\]

were \(b_i^2\) was square of regression coefficient for genotype, and the term \(\sum_{j=1}^{m} Y_{ij}^2\) was sum of squares of dependent variable (genotype).

All data were subjected to analysis of variance for each character using MSTAT-C (version 2.1 Michigan State University of Texas at Austin). The significant of genotype, year and cultivar x year (Environment) interactions were determined at 0.05 and 0.01 probability levels, by the F-test. The F protected least significant difference (LSD) was calculated at 0.05 probability level according to Steel & Torrie (1980).

Results and Discussion

Differences among cultivars for seed yield were not significant in 1988, 1990, 1995 and 1996, but these differences were significant \((p<0.01)\) in other years. Differences among blocks were significant only in 1989 \((p<0.01)\) and 1995 \((p<0.05)\). In the analyses of variance for seed yield combined across years, differences among years, blocks, and cultivars were significant \((p<0.01);\) however, relative differences among cultivars were not consistent across years as indicated by the significant \((p<0.01)\) cultivar x year interaction.

This, feature appear itself by the interaction between year and cultivar being statistically significant throughout the experiment period. Considering the components obtained through division of cultivar-year \((C-Y)\) variance, it is seen that the significance of year-cultivar \((C-Y)\) interaction variance originates from the difference of regression coefficients of the cultivars. In fact that, cultivar x year interaction in the analyses of variance was accepted as genotypes x environment interaction. Because the years were considered as an environment in the study. Grain yield values of the cultivars are given in Table 1 and Fig. 3 for single years and as the overall mean of nine years.
### Table 1. Mean seed yield (kg ha\(^{-1}\)) of wheat cultivars across nine years.

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</tr>
</thead>
<tbody>
<tr>
<td>Momitchill</td>
<td>5610</td>
<td>3660</td>
<td>ab</td>
<td>6550</td>
<td>4660</td>
<td>a</td>
<td>6910</td>
<td>abc</td>
<td>7390</td>
<td>5700</td>
</tr>
<tr>
<td>Katea-1</td>
<td>4920</td>
<td>3930</td>
<td>a</td>
<td>6630</td>
<td>2610</td>
<td>de</td>
<td>7240</td>
<td>ab</td>
<td>7990</td>
<td>6300</td>
</tr>
<tr>
<td>Atilla-12</td>
<td>4380</td>
<td>4830</td>
<td>a</td>
<td>5660</td>
<td>4250</td>
<td>ab</td>
<td>6250</td>
<td>cd</td>
<td>6750</td>
<td>5360</td>
</tr>
<tr>
<td>Kirkpınar-79</td>
<td>4500</td>
<td>3870</td>
<td>a</td>
<td>5100</td>
<td>3610</td>
<td>bc</td>
<td>7520</td>
<td>a</td>
<td>7830</td>
<td>5030</td>
</tr>
<tr>
<td>Tosun-22</td>
<td>5480</td>
<td>4650</td>
<td>a</td>
<td>4810</td>
<td>3120</td>
<td>cd</td>
<td>5790</td>
<td>d</td>
<td>6120</td>
<td>4460</td>
</tr>
<tr>
<td>Gemini</td>
<td>4840</td>
<td>2240</td>
<td>c</td>
<td>4750</td>
<td>1870</td>
<td>c</td>
<td>6600</td>
<td>bc</td>
<td>6870</td>
<td>5370</td>
</tr>
<tr>
<td>Cumhuriyet-75</td>
<td>4470</td>
<td>2520</td>
<td>bc</td>
<td>4780</td>
<td>2350</td>
<td>de</td>
<td>6580</td>
<td>bc</td>
<td>7270</td>
<td>4920</td>
</tr>
</tbody>
</table>

L.S.D (0.05) NS 118.5 NS 84.17 77.24 89.12 66.27 NS NS 32.97

According to mean of nine years, four of the seven soft wheat cultivars had higher yields than the mean of trial (5310 kg ha\(^{-1}\)). These higher yielding cultivars were Momitchill (5920 kg ha\(^{-1}\)), Katea-1 (5690 kg ha\(^{-1}\)), Atilla-12 (5470 kg ha\(^{-1}\)) and Kirkpınar-79 (5440 kg ha\(^{-1}\)). The cultivars Momitchill and Katea-1 were in the same statistical group, whereas cvs Katea-1, Atilla-12 and Kirkpınar-79 formed a different group. The cultivars Tosun-22, Gemini and Cumhuriyet-75 had a lower yield value compared with the mean of trial (5310 kg ha\(^{-1}\)), giving the yields of 4930 kg ha\(^{-1}\), 4930 kg ha\(^{-1}\) and 4770 kg ha\(^{-1}\), respectively.

![Fig. 3. Mean seed yield (kg ha\(^{-1}\)) of wheat cultivars across nine years.](image)
The analysis of variance indicated that the mean square of homogeneity of regressions belonging to cultivars was statistically significant, whereas the regression biased mean squares was non significant. The regression coefficients of cvs Momitcell, Katea-1 and Kirkpınar-79 were found to be equal to the mean regression coefficient value, i.e., 1, as shown in Table 2 and Fig. 4. The regression coefficient (bi) of cultivar Gemini was not statistically significant although it was higher value than the mean regression coefficient (b =1). No significance of the regression coefficient (bi) of cv Gemini was due to the high error variance associated with this cultivar. The regression coefficients of cvs Atilla-12 and Tosun-22 were determined to be lower than 1, whereas that of cv Cumhuriyet-75 was found to be higher than 1. Statistically significant values were obtained in all cultivars with respect to the determination coefficient values.

The results showed that all 7 cultivars were stable according to the Bree's determinations, considering only the regression-biased square means. However, when the regression coefficients are also considered as an indication of stability, beside the variance of deviations from regression, Momitcell, Katea-1, Kirkpınar-79 and Gemini were found to be stable (S²Yₓi = S² and bi=b), while cvs Atilla-12, Tosun-22 and Cumhuriyet-75 were not stable (Eberhart & Russell, 1966). When the determination coefficient (r²), another statistical parameter, used with the regression-biased square means was considered, all cultivars were found to be stable.

The classification made depending on regression coefficient values accordingly, it can be concluded that cv Cumhuriyet-75 (7) is adapted to good conditions, while cvs Atilla-12 (3) and Tosun-22 (5) are adapted to unfavorable conditions. Moreover it was determined that among the cultivars Momitcell(1), Katea-1(2) and Kirkpınar-79 (4) were well-adapted to all environments with their yields 5920, 5690 and 5440 kg ha⁻¹, respectively which were higher than the trial mean (5310 kg ha⁻¹), whereas cv Gemini (6) was poor adapted to all environments with yield of 4930 kg ha⁻¹. Schematic representation of the adaptabilities of cultivars was presented in Fig. 4 and 5.

Conclusion

This study has provided evaluation of the environmental and yield performance of some soft wheat cultivars. According to the analysis of variance, differences between years and cultivars, and cultivars x year interaction effects were significantly found for grain yield. Differences temperature and precipitation among years were environmental factors that had a major effect on wheat yield. Stability analysis indicated that there were stable cultivar for grain yield, whereas some cultivars were considered as having high adaptability to good environments and the other several cultivars to the unfavorable conditions. The cultivars Momitcell (1), Katea-1 (2) and Kirkpınar-79 (4) were determined as the most suitable cultivars for the ecology of region, depending on the results of trials which had been carried out at Bursa location for 9 years (Fig. 5). These cultivars may be recommended for wheat production areas in Marmara region due to their stability and well-adaptability to all environments. Nevertheless, cv Cumhuriyet-75 (7) may also be recommended for favorable conditions although it was not determined to be stable with respect to its regression coefficient, for example, in case that very rich soil conditions are implemented. On the other hand, cv Gemini (6) was badly adapted to all environment conditions, while Tosun-22 (5) and Atilla-12 (3) had adaptability to poor environment conditions.
Table 2. The Statistics of adaptation and stability of experimented wheat cultivars.

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>$b_i$</th>
<th>$S_{Y_{XI}}$</th>
<th>$r_i^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montebill</td>
<td>0.847</td>
<td>8733</td>
<td>0.86**</td>
</tr>
<tr>
<td>Katea-1</td>
<td>1.261</td>
<td>5045</td>
<td>0.96**</td>
</tr>
<tr>
<td>Atilla-12</td>
<td>0.610*</td>
<td>5465</td>
<td>0.85**</td>
</tr>
<tr>
<td>Kirkpinar-79</td>
<td>1.109</td>
<td>8102</td>
<td>0.93**</td>
</tr>
<tr>
<td>Tosun-22</td>
<td>0.560*</td>
<td>10177</td>
<td>0.70*</td>
</tr>
<tr>
<td>Gemini</td>
<td>1.340</td>
<td>11890</td>
<td>0.92**</td>
</tr>
<tr>
<td>Cumhuriyet-75</td>
<td>1.273**</td>
<td>1056</td>
<td>0.90**</td>
</tr>
</tbody>
</table>

Mean 1.000

* , ** Significantly different at $p=0.05$ and $p=0.01$, respectively

$b_i$=Regression coefficient; $S_{Y_{XI}}$=Regression-biased square means; $r_i^2$=coefficient of determination

Fig. 4. Classification of cultivars according to their adaptabilities.

Fig. 5. Mean seed yield (kg ha$^{-1}$) of wheat cultivars across nine years.
References


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